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WAC FOR CYBORGS

DISCURSIVE THOUGHT IN INFORMATION RICH ENVIRONMENTS

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It isn't easy being a cyborg these days. The human wetware constantly needs rewiring to remain compatible with the latest software and hardware options. When I was a young cyborg, back in the 1950s, the work component of my cognitive and affective system mainly needed compatibility with the well evolved and fairly stable print world. The entertainment component needed compatibility mainly with passive reception of audio and video delivered at the pace of unaugmented life—although people were already complaining that their lives were being fragmented by too many choices and commercial interruptions.

Through my education I wired myself well to the print world, as organized and delivered through the university system of disciplinary knowledge production, distribution, and use. I rose through the ranks until I got to support newer cyborgs as they wired themselves into the knowledge system. I thought the best way to provide access to educational opportunity was to unpack all I had learned about operating in the print world, thereby demystifying the cultural capital that middle-class life and elite education had afforded me. Others could then use those skills for their own purposes in relation to their own experiences and knowledge.

As I gained experience teaching, I met an ever-wider set of cyborgs with different orientations, motives, resources, and compatibilities with different parts of the knowledge system. My familiarity with the knowledge system expanded, as well. Technology upgrades required some minor personal rewiring, but xerography, word processing, even early email were easy to assimilate within my existing ways of working and thinking.

But the last 10 years have heightened cyborg challenges for me as it did for others. The human component needed major reconfiguration to work with the external knowledge systems and multidimensional communicative relationships that are becoming standard in many professions, as various people have started to explore. Sherry Turkle, for example, has examined changing identity and self-conception through close relation with the computer and computer-mediated communication and forums. The work on cognitive and affective change in children spending many hours on video games, particularly as those games model police training to overcome anxiety and focus attention in firearms situations, suggest some of the issues. I, along with others, have started to explore some of the changes in participation frames and social organizations being afforded by web-mediated activities (see, e.g., Yates and von Maanen and Bazerman "Genre").

One human cyborgian challenge for most students, academics, and professionals results from the accessibility to and machine analyzability of large data sets. Of course, large accumulations of data are not new to this generation. Detailed astronomical data go back millennia, as do maps and other forms of geographical recording. Modern accounting practices go back to the 14th century, and since then have generated extensive commercial records. Colonial empires, the development of science, the modern bureaucratic state, systematic agriculture, the large corporation, transportation systems—all have increased the need and means for gathering and keeping extensive data. For the most part, however, these extensive files of data would only be examined and used by people trained and experienced in the area. Often, such experience included experience of the material realities recorded by the data. Extraction and manipulation of the data were also often done manually, often by the same people who collected and would use the data. Displays of the data, by and large, were close to the original form—complex graphic and tabular display only came gradually for the most expert users. Consider, for example, the ways numerical and displays in science articles only flowered in arcaneness in the last 200 years (Bazerman *Shaping*). Or consider that vertical filing cabinets are less than 150 years old, and the Hollerith system of data extraction (the precurser to the IBM card) is only about 120 years old (see Yates; Lubar). Nonspecialist use of data sets, historically, then, was limited and often required training—as with reading maps and train schedules.

In schools, too, for many reasons, the amount and form of information students had access to and had to make sense of was limited. In 18th-century elementary classrooms students might have access to the alphabet and a few words and phrases on a hornbook—and that was it. Later, a few textbooks of the McGuffey sort entered the picture. Until the advent of the computer, even in well-funded school districts, students received information primarily predigested in a series of subject matter textbooks—where the selection and meaning and activities were all set out. Students had to address only the most limited problems with defined data, as in arithmetic exercises or end-of-the-chapter history questions. Even the advanced learning in the talmudic tradition involved only a few books, with all the multiple voices on each passage visually available on the same page. Similarly, in Western higher education, students frequently did not need to know much beyond the professor's lecture and the notes they took on it, perhaps supplemented by assigned reading. Even reliance on the material for prerequisite courses may have been sporadic.

Occasionally, students at all levels, might be sent to the library to locate other resources, but as a whole the knowledge universe has remained tightly circumscribed, controlled, and already interpreted. The thing most like a data set I remember from my 1950s childhood were tables of logarithms and trigonometric functions—whose use and meaning were determined by algorithmic procedures. They were treated mechanically and not as matters for interpretation or understanding. The main place where an open-ended richness was to be found was in the library—and the ill-defined research paper became the one potential site of inquiry and discovery. When I began to teach and study writing in higher education I was quickly attracted to the research paper, which then led me into fundamental question of knowledge use, understanding, and production in disciplinary contexts. Coming to know the literate system of knowledge texts—how to find your way around a library and a disciplinary literature—was to learn how to access and think about what the academy had to offer. Immersion in disciplinary databases was something that only the most advanced students would get to, often only in graduate education, and perhaps only in the more advanced years of graduate work.

This collection, interpretation, and use of data defines much of professional practice. The competence to find one's way within relevant data, to know how to manipulate and think about it, licenses the professional as professional, in industry and public practice as well as in the academy. The problems of making sense of data for professionals is not trivial, but professionals have whole careers to work their way into the competence—a competence that often distinguishes the skill and presumed intelligence of people at the highest levels. The search for data starts from a basis of contextual knowledge about the subject matter, the kinds of data typically available in the field, and the typical uses of data. The data search or gathering also starts from a set of purposes and projects that would be aided by the data. Also needed early in the process is knowledge of where the appropriate data is to be found and how to access it. Because the data often are not direct representations of the phenomenon being considered, but only some indicator or surrogate for the phenomenon (e.g., test scores to indicate learning, questionnaire responses to indicate attitudes), the savvy researcher understands the relationship between the mapping device and the territory. Furthermore, the knowledgeable inquirer needs to know the kinds of manipulations and analyses he or she can legitimately and conveniently make of the data in order to answer more subtle questions than can be answered directly by unprocessed data.

Now computers and the Internet have changed the game radically. Data are exchanged rapidly and cheaply among colleagues, and extensive electronic archives are set up and easily accessed and/or distributed. Many electronic instruments also collect extensive data easily with limited human set-up, guidance, and examination. We are awash with data.

Furthermore, because manipulations are now also frequently and complexly automated, even before the user sees the data, at some point knowledge of how the system manipulates and transforms the data is important for the expert to understand. The power of computing has facilitated the building of complex models of complex systems, such as of global warming or a nation's economy. The outputs of these complex models are highly transformed from the original data, and again an inquirer is more enabled the more he or she understands of what the model does. Similarly, forms of representation, such as tables or graphs, have long involved transformations of data into new forms that make them readable in different ways, ways that highlight different aspects and meanings of the data. The data user again needs to understand the consequences of the forms of data representation. The electronic world has made that problem even greater through bit-mapping, which allows many new and creative forms of visual and audio display that are many removes in appearance from the original phenomena, as when the stock market becomes a field of wheat or a flock of birds. These forms of representation, both old and new, are usually in the service of finding and displaying meaningful patterns and significant consequences; the skill in finding the most powerful of such meanings is one of the key attributes of experts.

Coordinately, expertise of many professions has been more explicitly defined around the ability to manipulate large amounts of data, and students are often given access to large amounts of data much earlier in their careers. Students not only have access to massive amounts of information, the information is often in undigested form or not placed within the frame of the learning task at hand. Often enough students get access to the exact same data bases that the professionals use. One project I work with, for example, is preparing for Internet access for elementary school children (along with every other age and level of student and scholar) to a massive video oral history archive of holocaust testimony consisting of more than 120,000 hours of digitized video. This contact with the real-world experience of the holocaust is to be used, for, among other purposes, inquiry-based tolerance education. This project is the first step of gaining other testimonies of similar experiences, and more generally of providing electronic access to all oral history and other historical archives. Historical archives were until recently rare, expensive, hard to collect, hard to get to—only credentialed scholars might be granted admission, and then they had to wear white gloves. Now first graders may have access to the same material. How can they use it well? How can kids make sense of the material? How can this material be part of their educational development? How will they adapt to growing up in such a data-rich environment?

Historically, the making sense of data has been associated with skills of expression and writing. Books and then journals were the repository of knowledge; libraries and universities were the places within which people explored and came to find the meaning in information, and writing was the vehicle largely by which they came to express, synthesize, and evaluate information. The greatest experts in information-rich fields were typically those who write about the knowledge of their field, at least to other specialists, and sometimes to wider audiences. As writing teachers we soon come to understand how much we are in the center of the process of students coming to intelligent terms with what they are learning and by which they come to be competent professional knowledge users. Our profession's extensive concern with academic writing, the research paper, critical writing, Writing Across the Curriculum (WAC), and Writing In the Disciplines indicate our profession's awareness of how much writing is intertwined with knowledge, information, and meaning-making.

However, with the easy accessibility of data and the attractiveness of exposing students to more extensive data earlier in their education, the need for students to articulate what they have found and to make sense of it has become greater and more pressing. They need the tools of more sophisticated writing earlier on and more universally. Not just the few who make their way over many hurdles that both train and exclude to become experts have to cope with data, but all students with little prior relevant experience have to understand the following:

- The purposes of consulting data

- The relevant contexts for their inquiry
- Access to the data
- Planning a methodical inquiry
- The logics of the data and the data systems, including complex models that produce secondary data
- The forms in which data are represented
- Manipulation and analysis of the data
- The human meaning of the data
- The patterns and concepts that suggest interpretation of the data
- The role that knowledge takes within their lives.

The problems of the traditional sort have been exacerbated by the tremendous power of computation. Databases are larger, accessible from a greater distance, and more likely to have little to do with students' immediate experience. Even more, the computer may manipulate the data in ways that may not be apparent to the user. The input data may be very different from what a user is likely to see. Techniques like bitmapping have extended the transformation of the representation far in excess of traditional graphing techniques. Various search, tracking, and analytic tools as well allow students and other users to do many things to the data. How can students make sense of what they are finding, what they are doing, what the data means? Students have to do a lot more thinking, at a higher level, as they provide them more to think about and as the machines do a lot of the preliminary thinking, or even appear to substitute their thinking for human thought. How can we integrate machine thinking with our thinking? What parts of the thinking is it appropriate to let the machines do? How can we think about what the machines have done? How can machines support our thinking? How do machines displace or narrow our thinking? How can we train people to be up to the challenge of figuring out what their knowledge and information means? For the time being, until someone comes up with another stronger task-appropriate thinking and articulating tool, writing must carry a strong educational burden, and student writing must be supported in useful way.

As university courses make greater use of professional databases for introductory and midlevel courses, WAC and Electronic Communication Across the Curriculum initiatives provide opportunities for us to explore how writing might help students develop the understanding they need to access, work with, and come to conclusions from the data. At UCSB, I have had the good fortune over the last several years to consult with Professor William Prothero on his large freshman course Geology 4: Introduction to

Oceanography. Since 1994 in lecture, lab, and at-home assignments, he has introduced students to the use and interpretation of geological and oceanographic databases in order to develop their abilities in the subject matter and more generally to think scientifically. From the beginning, he has been interested in incorporating writing as a way to help students develop and express their thinking, and I have consulted with him on the organization of the writing activities. Professors Greg Kelly and Allison Takao have also studied this project, including examination of the arguments students make in their writing (Kelly and Takao; Takao, Prothero, and Kelly). Currently, another graduate student, C. Julie Esch, under my supervision, has been studying how students learn to associate data with higher level generalizations, and she has been developing some additions to the course materials, activity, instruction, and guidance for teaching assistants (TAs) to support student writing.

The most thorough integration of writing now occurs in the first third of the course, as students are introduced to oceanographic data and are asked to develop a seven- to eight-page mid-term paper. In the paper the students are asked to observe, identify, classify, and describe earth data and then argue how they relate to the theory of plate tectonics. The data, which is made available for lab and home use on a CD, "Our Dynamic Planet," consists of the ETOPO5 data set of land and sea floor elevations, the Smithsonian Global Volcanoes data set, the earthquake data set from the World-Wide Network of Seismic Stations, and a Heat Flow Data Set provided by Professor Carol Stein of Northwestern University. These are the same data sets used by professional earth scientists. These data are displayed not as raw numbers, but in map formatted graphic displays and as cross-section profiles.

By use of tools and tutorials developed by Professor Prothero over the years, students are guided in accessing and manipulating the data sets. To help students identify features from the mapped displays the CD-based lab provides them with several games. Through the games, the students learn to identify three-dimensional objects from two- dimensional displays, to associate elevation profiles with descriptive names, to identify key data items, to make some basic inferences, and, most subtly of all, to determine which selection of the data will be most useful in answering their questions. Simultaneously, they are introduced to the basics of plate tectonic theory and how various identifiable topographic features are created by tectonic processes. The theory is regularly tied back to the mapped data.

These tools and training devices were developed in response to student difficulties in handling and interpreting the basic data sets. When I first discussed this project with Professor Prothero about 5 years ago, he already had most of these pieces in place, including the long mid-term paper, supported by a 10-page guide for writing a scientific paper with a short checklist on proper format. He was concerned, however, that students in their papers, were not able to demonstrate adequate scientific reasoning, which for him meant coming up with arguments supported by good reasons and appropriate data. I suggested to him standard WAC advice—he should provide some smaller, less ambitious paper assignments and students should have an opportunity for peer-editing groups before turning in the assignments. I also suggested that he provide some rubrics and questions to guide the peer reviewing sessions. He then developed a three-page, small area description assignment. In this assignment, students had to work with a limited section of the mapped data to identify the geologic features in it and explain how the features might be related to a plate boundary. The paper was to consist of only one page of text, one page of figures, and one page of a self-assessment checklist. He also developed an author feedback form to guide peer-group discussions. He has also expanded the guide to writing a scientific paper to almost 20 pages.

Although adding the preliminary shorter assignment did seem to improve student writing, Professor Prothero was still concerned that many students were not understanding how to support their general claims well with data. There was the further problem that the geology graduate TAs were not providing consistent or pedagogically helpful correction and commentary on student papers, despite a detailed grading rubric. He still sensed there was something more to be articulated what good scientific writing consisted of, in this context.

To start to see where student arguments were succeeding and failing, Professors Kelly and Takao analyzed a sample of the student papers, using a model of argumentation that considered the different epistemic levels of argument and how those levels were integrated. To analytically specify Bruno Latour and Steve Woolgar's sequence of different levels of epistemic certainty a claim might reach, they followed my suggestion to adapt James Britton's seven types of transactional argument as a tool for analyzing sentence types. Britton et al. identify the various levels of transactional discourse as record, report, generalized narrative, analogic (low level of generalization), analogic, analogic-tautologic (speculative), and tautologic (argument carried out fully on the level of abstractions). Many years ago, I had played around with using these categories as sentence-level descriptors to help students recognize how different sentences and paragraphs might be integrated through hierarchically arranged levels of generalization or intellectual abstraction. Although I found the taxonomy worked well as a revision heuristic, I did not pursue it at that time. Kelly and Takao adapt-ed this taxonomy to identify epistemic levels of sentences using the task-specific categories, going from the most concrete to the most theoretical:

- Data charts, representations, locations, and age of islands
- Topographical features identified
- Relational aspects of geologic structures
- Geologic theory or model illustrated with real earth samples
- General geologic theory or model
- General geologic knowledge not specified to data presented.

The better rated papers, they found, had far more statements at all levels, with a substantial number of sentences at the middle epistemic levels to bridge between the most concrete and the most abstract. Furthermore they found there were specific reference linkages among claims made at different levels, with few big jumps of level in the links. Figure 6.1, for example, is the map of the sentences in one of the papers that was highly rated wholistically by disciplinary graders.

On the lower rated papers, however, there were fewer sentences at all levels, with particular absence at the lower or middle epistemic levels. Furthermore, there were fewer linkages between claims, and what linkages there were jumped across levels. Figure 6.2, for example, maps the epistemic levels and linkages of a paper rated poorly by disciplinary assessors.

This mapping of epistemic levels and linkages made visible some key aspects of arguing well, although expert evaluation of the sample suggested that other factors such as problem formulation, focus, and accurate inferencing were also important. Other issues that seem important are the understanding the argumentative power of different and multiple sorts of data and the use of figures. Nonetheless, the findings on the levels of claims model were strong enough to warrant explicit instruction and guidance about the kind of claims that needed to be made and how they should be linked. C. Julie Esch then developed several interventions on this theme, which were incorporated into the Spring 2000 version of the course. First was an exercise in the lab book that helped students identify in sample essays statements at different epistemic levels and linkages made between those levels. Students were to do this exercise before writing the small area description. Second, she developed an author self-analysis form. Third, she revised the feedback form used in peer-group sessions to reflect the epistemic levels model. These levels and rubrics were then used to orient TAs and modify grading rubrics. During TA training, Esch introduced the TAs to the model and related writing issues. Students reported this support was extremely helpful.

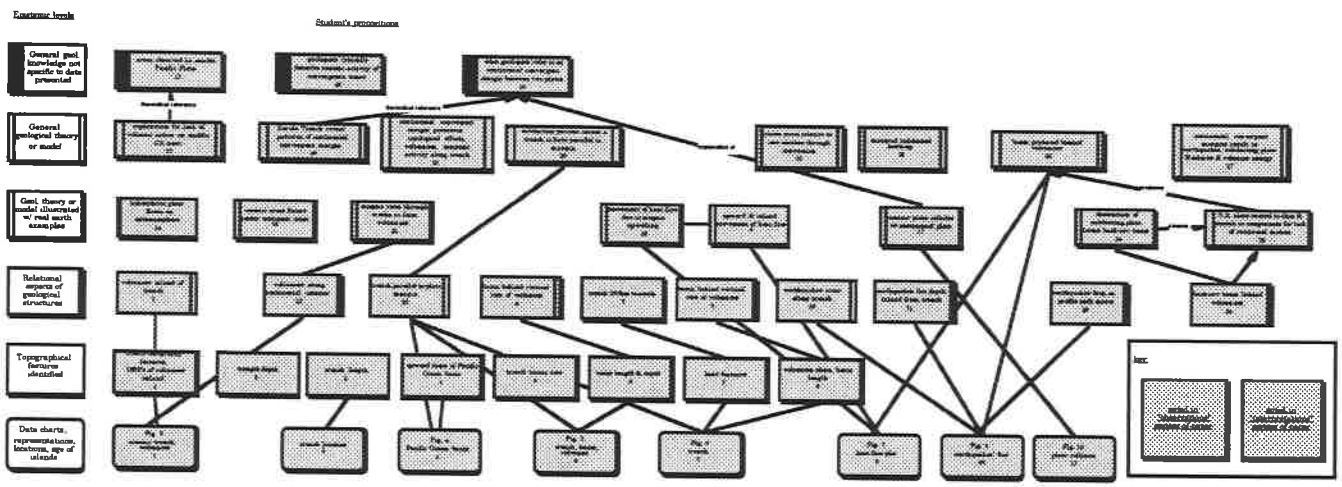

FIGURE 9.1. Epistemic levels in a highly rated paper. (From Kelly and Takao.)

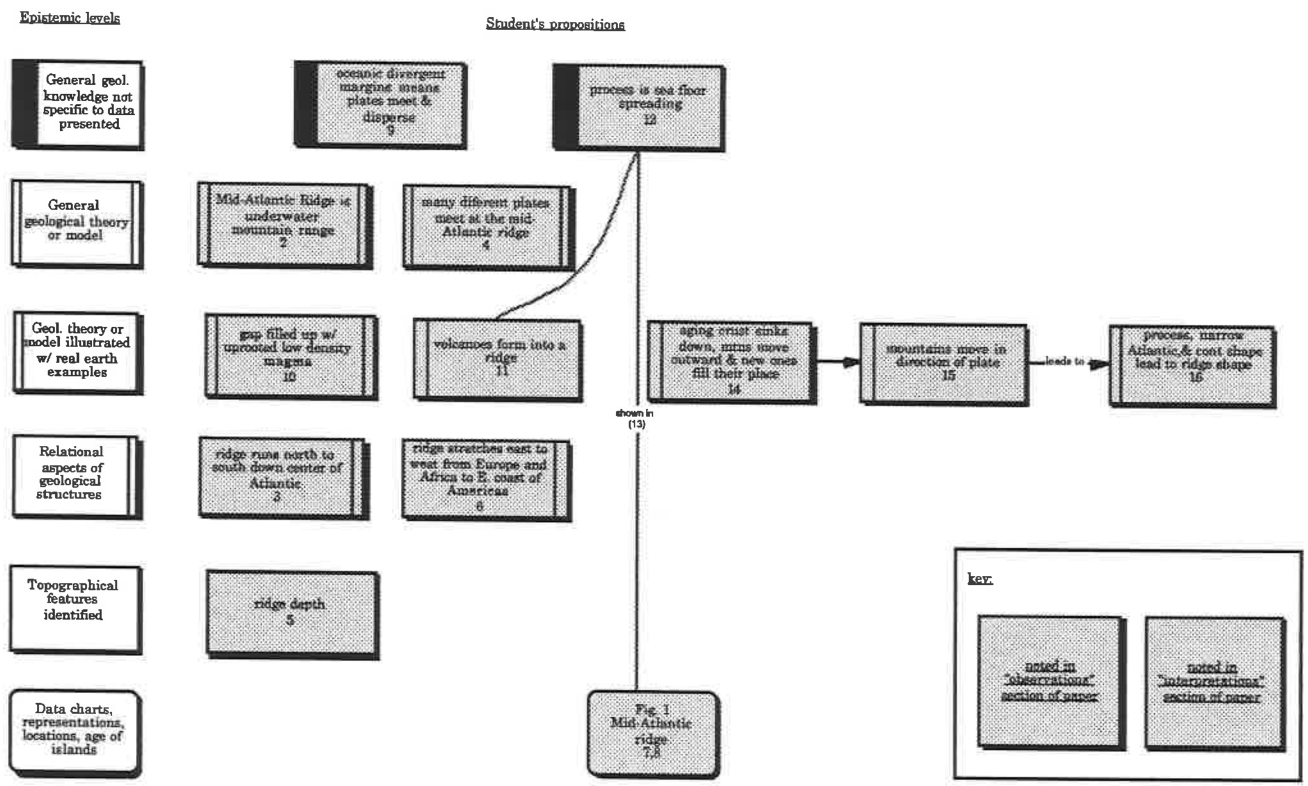

FIGURE 9.2. Epistemic levels in a lower rated paper. (From Kelly and Takao.)

Such studies suggest the kind of difficulties students have in making sense of and arguing from data with some theoretical sophistication. When students write, their lack of understanding of the meaning of data and the relation to larger ideas becomes evident. This project also suggests how we may begin to provide more specific writing support that will give students the kind of help they need to cope with the complex intellectual and human demands the information is placing on them.

If we really believe that writing is the vehicle for understanding, learning, and human meaning-making, then these are the fields on which we now need to play. The work is demanding and the interdisciplinary collaboration is serious. But the consequences are large. The kinds of courses with which we have been working are being funded at high levels with the hope that they will be models for a new generation of courses, if not themselves directly reproduced. The production of cyborgs is now a large- scale proposition.

Educational programs that mix humans with machines highlight the fact that human intelligence is a major component of cyborgian intelligence. The future of cyborgian intelligence requires we go beyond just making smarter machines or even making more user-friendly interfaces that allow humans to work easily with the machine enhancements. Humans too must develop to act intelligently in coordination with their machine supplements. Writing is one of the major vehicles by which people actively develop their thought. By incorporating writing in our new forms of supported thought, we help people figure out what all this new information and knowledge means and what it is useful for. We also help them maintain connection with the complex resources of human intelligence and wisdom that we have developed over millennia of literacy.

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